

WHAT IS CLAIMED IS:

1 1. A method for treating a surface of a substrate, the method comprising:

2 (a) forming active sites on a carbon-containing substrate surface by

3 exposing the substrate surface to a plasma;

4 (b) reacting a first gas comprising spacer molecules with the active sites *in*

5 *situ* in the absence of plasma to provide surface-bound spacer chains; and

6 (c) reacting a second gas comprising spacer chain extender molecules with

7 the surface-bound spacer chains *in situ* in the absence of plasma to provide extended spacer

8 chains, wherein the extended spacer chain comprises at least one reactive functional group

9 that is not a chloracid group.

1 2. The method of claim 1, further comprising immobilizing biomolecules

2 on the substrate surface by reacting the biomolecules with the at least one reactive functional

3 group of the extended spacer chains.

1 3. The method of claim 1, wherein the substrate is a polymeric substrate.

1 4. The method of claim 3, wherein the substrate comprises a polymer

2 selected from the group consisting of polyethylene, polystyrene, polycarbonate, polymethyl

3 methacrylate and polypropylene.

1 5. The method of claim 1, wherein the substrate comprises

2 polytetrafluoroethylene.

1 6. The method of claim 1, wherein the substrate comprises a diamond-

2 like carbon film.

1 7. The method of claim 1, wherein the substrate comprises a carbon

2 nanoparticle.

1 8. The method of claim 7, wherein the substrate comprises a carbon

2 nanotube.

1 9. The method of claim 1, wherein the substrate comprises a material

2 selected from the group consisting of diamond and graphite.

1 10. The method of claim 1, wherein the first gas comprises diamine
2 molecules.

1 11. The method of claim 10, wherein the diamine molecules are
2 ethylenediamine molecules.

1 12. The method of claim 1, wherein the first gas comprises diepoxide
2 molecules.

1 13. The method of claim 12, wherein the diepoxide molecules comprise
2 1,4-butanediol diglycidyl ether molecules.

3 14. The method of claim 1, wherein the second gas has a vapor pressure of
4 at least about 200 mTorr at 20°C.

1 15. The method of claim 1, wherein the second gas comprises dialdehyde
2 molecules.

1 16. The method of claim 15, wherein the dialdehyde molecules are glutaric
2 dialdehyde molecules.

1 17. The method of claim 1, wherein the second gas comprises anhydride
2 molecules.

1 18. The method of claim 17, wherein the anhydride molecules are
2 hexafluoroglutaric anhydrides molecules.

1 19. The method of claim 1, wherein the second gas comprises dichloride
2 molecules.

1 20. The method of claim 19, wherein the dichloride molecules are
2 dimethyldichlorosilane molecules.

1 21. The method of claim 10, wherein the second gas comprises diepoxide
2 molecules.

1 22. The method of claim 21, wherein the diepoxide molecules are 1,4-
2 butanediol diglycidyl ether molecules.

1 23. The method of claim 1, wherein the plasma is an argon plasma.

1 24. The method of claim 1, wherein the plasma is an argon and hydrogen
2 plasma.

1 25. The method of claim 1, wherein the plasma is a hydrogen plasma.

1 26. The method of claim 2, wherein the biomolecule is selected from the
2 group consisting of oligonucleotides, aptamers, cDNA and RNA.

1 27. The method of claim 2, wherein the biomolecule is an protein.

1 28. The method of claim 2, further comprising exposing the immobilized
2 biomolecules to a reducing agent.

1 29. A method for treating a surface of a substrate, the method comprising:

2 (a) forming active sites on a carbon-containing substrate surface by
3 exposing the carbon-containing substrate surface to a plasma; and

4 (b) reacting a first gas comprising spacer molecules having at least two
5 different reactive functional groups with the active sites *in situ* in the absence of plasma to
6 provide surface-bound spacer chains.

1 30. The method of claim 29, wherein the spacer molecules comprise

2 epihalohydrin molecules.

1 31. The method of claim 29, further comprising immobilizing

2 biomolecules on the substrate surface by reacting the biomolecules with the surface-bound
3 spacer chains.

1 32. A method for treating a surface of a substrate, the method comprising:

2 (a) forming active sites on a carbon-containing substrate surface by
3 exposing the carbon-containing substrate surface to a plasma;

4 (b) reacting a first gas comprising spacer molecules with the active sites *in*
5 *situ* in the absence of plasma to provide surface-bound spacer chains;

6 (c) reacting a second gas comprising spacer chain extender molecules with
7 the spacer chains *in situ* in the absence of plasma to provide extended spacer chains; and

8 (d) reacting a third gas comprising spacer chain extender molecules with

9 the extended spacer chains *in situ* in the absence of plasma to further extend the spacer
10 chains.

1 33. The method of claim 32, further comprising immobilizing
2 biomolecules on the substrate surface by reacting the biomolecules with the further extended
3 spacer chains.

1 34. A method for treating the surfaces of carbon-containing nanotubes or
2 nanoparticles, the method comprising:

3 (a) forming active sites on the surfaces of carbon-containing nanotubes or
4 nanoparticles by exposing the nanotubes or nanoparticles to a plasma; and

5 (b) reacting a first gas comprising spacer molecules with the active sites *in*
6 *situ* in the absence of plasma to provide surface-bound spacer chains.

1 35. The method of claim 34, further comprising reacting a second gas
2 comprising spacer chain extender molecules with the surface-bound spacer chains to provide
3 extended spacer chains.

1 36. The method of claim 35, further comprising immobilizing
2 biomolecules on the nanotubes or nanoparticles by reacting the biomolecules with the
3 extended spacer chains.

1 37. A method for treating a diamond-like carbon surface, the method
2 comprising:

3 (a) forming active sites on the diamond-like carbon surface by exposing
4 the surface to a plasma; and

5 (b) reacting a first gas comprising spacer molecules with the active sites *in*
6 *situ* in the absence of plasma to provide surface-bound spacer chains.

1 38. A carbon-containing surface comprising:

2 (a) a carbon-containing surface;

3 (b) spacer chains covalently bound to the carbon-containing surface, the
4 spacer chains formed by reacting molecules selected from the group consisting of
5 epichlorohydrin, epibromohydrin, epifluorohydrin, 1,4-butanediol diglycidyl ether and
6 combinations thereof with the surface; and

7 (c) biomolecules covalently bound to the spacer chains.

1 39. A surface treated carbon-containing nanotube or nanoparticle
2 comprising:
3 (a) a carbon-containing nanotube or nanoparticle;
4 (b) spacer chains covalently bound to the nanotube or nanoparticle; and
5 (c) biomolecules covalently bound to the spacer chains;
6 wherein the spacer chains are formed from molecules selected from the group
7 consisting of dialdehyde molecules, anhydride molecules, dichloride molecules,
8 epihalohydrin molecules, diepoxide molecules and combinations thereof.

1 40. A surface treated diamond-like carbon film comprising:
2 (a) a diamond-like carbon film;
3 (b) spacer chains covalently bound to the diamond-like carbon film; and
4 (c) biomolecules covalently bound to the spacer chains;
5 wherein the spacer chains are formed from molecules selected from the group
6 consisting of dialdehyde molecules, anhydride molecules, dichloride molecules,
7 epihalohydrin molecules, diepoxide molecules and combinations thereof.

1 41. The diamond-like carbon film of claim 40, wherein the diamond-like
2 carbon film is disposed on a substrate.

1 42. A carbon-containing substrate comprising:
2 (a) a carbon-containing substrate surface;
3 (b) one or more molecular spacer chains covalently bound to the surface,
4 the one or more spacer chains having a length of at least 2.5 nm; and
5 (c) one or more biomolecules covalently bound to the one or more
6 molecular spacer chains.

1 43. The substrate of claim 42, wherein the substrate surface comprises a
2 polymeric surface.

1 44. The substrate of claim 42, wherein the substrate surface comprises a
2 diamond-like carbon film.

1 45. The substrate of claim 42, wherein the substrate surface comprises a
2 carbon nanotube or carbon nanoparticle surface.

1 46. The substrate of claim 42, wherein the one or more spacer chains have
2 a length of at least 4 nm.

1 47. The substrate of claim 42, wherein the one or more spacer chains have
2 a length of at least 5 nm.

1 48. The substrate of claim 42, wherein the one or more biomolecules are
2 proteins.

1 49. The substrate of claim 42, wherein the one or more biomolecules are
2 enzymes.

1 50. The substrate of claim 42, wherein the one or more biomolecules are
2 oligonucleotides.